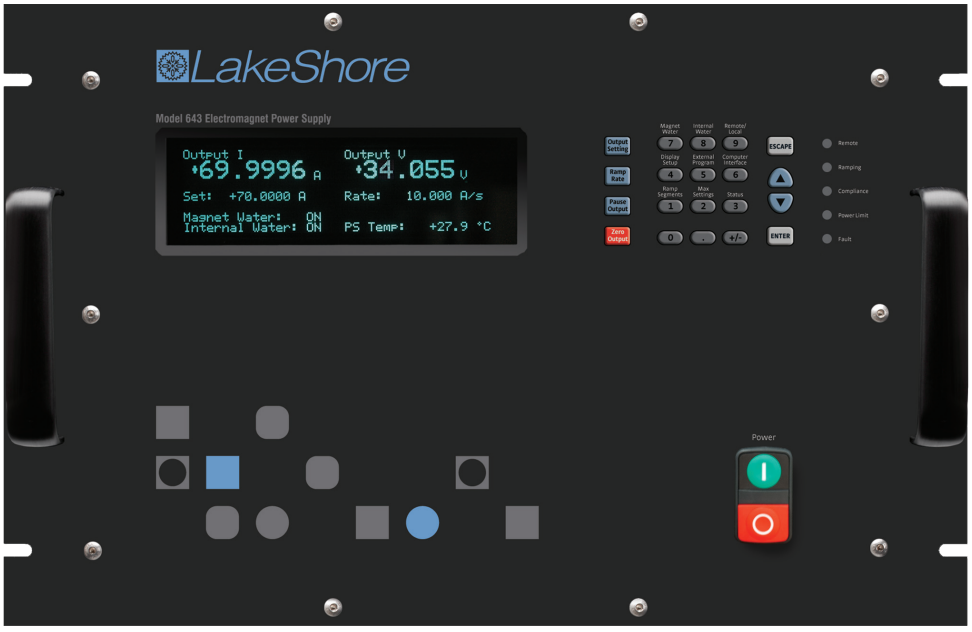
# Model 643 Electromagnet Power Supply

- Bipolar, linear, true 4-quadrant output
- ±70 A/±35 V, 2450 W
- Can be modulated to frequencies up to 0.17 Hz at ±70 A
- Low noise
- 0.1 mA of programmed current resolution
- Analog programming and IEEE-488 and USB interfaces
- Built-in fault protection
- Compact design




## Introduction

The Model 643 electromagnet power supply is a linear, bipolar current source providing true 4-quadrant output, eliminating the need for external switching or operator intervention to reverse current polarity. The Model 643 is capable of supplying ±70 A/±35 V to a nominal 0.5 Ω, 0.5 H load, and the output can be modulated from an external source to frequencies up to 0.17 Hz at ±70 A. Internally programmed output provides 20-bit resolution, while externally programmed output provides unlimited resolution.

The compact, low noise design of the Model 643 makes it the ideal supply for use in laboratory settings. When combined with a Lake Shore EM4 4-inch electromagnet and Model 475 DSP gaussmeter, the Model 643 provides a versatile field control system ideal for a wide range of user defined applications. These include but are not limited to magneto-optical, magnetic hysteresis and susceptibility, and Hall effect measurements, as well as in-line annealing.

## Output architecture

The Model 643 output architecture relies on low noise linear input and output stages. The linear circuitry of the Model 643 permits operation with less electrical noise than switch-mode electromagnet power supplies. The clean field background allows greater resolution and finer detail in results drawn from data taken during high sensitivity experiments. One key benefit of this architecture is CE compliance to the electromagnetic compatibility (EMC) directive, including the radiated emissions requirement.

The true 4-quadrant output capability of the Model 643 is ideal for sweeping through both positive and negative fields. Tightly integrated analog control of the 4-quadrant output provides smooth current change with very low overshoot. This eliminates the need for external switching or operator intervention to reverse the polarity, significantly simplifying system design. The transition through zero current is smooth and continuous, allowing the user to readily control the magnetic field as polarity changes. This is achieved without reversal contactors or relays, which would produce unintended field spikes and other discontinuities. As a result, field hysteresis and other biases are avoided in the experimental data.

## Output programming

The Model 643 output current is programmed internally via the keypad or the computer interface, externally by analog programming input, or by the sum of the external and internal settings. For internal programming, the Model 643 incorporates a proprietary 20-bit digital-to-analog converter (DAC) that is monotonic over the entire output range and provides resolution of 0.1 mA. External programming provides unlimited resolution.

The Model 643 generates extremely smooth and continuous ramps with virtually no overshoot. The digitally generated constant current ramp rate is variable between 0.1 mA/s and 50 A/s. To ensure smooth ramp rate, the power supply updates the high-resolution DAC 23.7 times per second. A low-pass filter on the output DAC smooths the transitions at step changes during ramping.

### Output reading
The Model 643 provides high-resolution output readings. The output current reading reflects the actual current in the magnet, and has a resolution of 0.1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 0.1 mV. All output readings can be prominently displayed on the front panel and read over the computer interface.

### Protection
The Model 643 provides built-in protection against short circuit, open circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, over temperature, and abrupt change of the external programming input. In the event of water flow failure, flow sensors provide feedback to the Model 643 and output current is set to 0 A. Internal heat sink, cold plate, and transformer temperatures are also monitored. Warnings are displayed before temperature limits are exceeded and current is set to 0 A. If temperatures continue to increase over safety limits, the Model 643 turns off.

A proprietary circuit limits the power dissipated in the water-cooled cold plate should low resistance and high line conditions exist. The Model 643 protects itself if operated into resistances outside of nominal limits. By limiting current output, the power supply will safely operate into a shorted load, and it operates safely into high resistance loads by limiting voltage output. The Model 643 is also protected against power loss under full operation and nominal magnet load. Both low and high power line conditions are reported on the front panel display.

### Interfaces
The Model 643 includes both parallel IEEE-488 and universal serial bus (USB) computer interfaces that provide access to operating data, stored parameters, and remote control of all front panel operating functions. The USB interface emulates an RS-232C serial port at a fixed 57,600 baud rate, but with the physical connections of a USB. This allows you to download firmware upgrades, ensuring your power supply is using the most current firmware version with no need for any physical changes. The Model 643 also provides two analog monitors for output current and voltage. Each monitor is a buffered, differential, analog voltage representation of the signal being monitored. The current monitor has a sensitivity of 7 V/70 A output, while the voltage monitor has a sensitivity of 3.5 V/35 V output.

### Display and keypad
The Model 643 incorporates a large 8-line by 40-character vacuum fluorescent display. Output current and output voltage readings are displayed simultaneously. Five front panel LEDs provide quick verification of instrument status, including ramping, compliance, fault, power limit, and computer interface mode. Error conditions are indicated on the main display along with an audible beeper. Extended error descriptions are available under the status key.

The keypad is arranged logically to separate the different functions of the power supply. The most common functions of the power supply are accessed using a single button press. The keypad can be locked in order to secure either all changes or just the instrument setup parameters allowing the supply output to be changed.

# Model 643 Specifications

## Output
**Type:** Bipolar, 4-quadrant, DC current source
**Current generation:** Fully linear regulation with digital setting and analog control
**Current range:** ±70 A
**Compliance voltage (DC):** ±35 V nominal
**Power:** 2450 W nominal
**Nominal load:** 0.5 Ω, 0.5 H
**Maximum load resistance:** 0.6 Ω for ±70 A DC operation at +10% to -5% line voltage
**Minimum load resistance:** 0.4 Ω for ±70 A DC operation at +5% to -10% line voltage
**Load inductance range:** 0 H to 1 H
**Current ripple:** 5 mA RMS (0.007%) at 70 A into nominal load
**Current ripple frequency:** Dominated by the line frequency and its harmonics
**Temperature coefficient:** ±15 ppm of full scale/°C
**Line regulation:** ±60 ppm of full scale/10% line change
**Stability (1 h):** 1 mA/h (after warm-up)
**Stability (24 h):** 5 mA/24 h (typical, dominated by temperautre coefficient and line regulation)
**Isolation:** Differential output is optically isolated from chassis to prevent ground loops
**Slew rate:** 50 A/s into nominal load, 100 A/s maximum into a resistive load
**Compliance voltage (AC):** ±43 V at +10% to -5% line
**Settling time:** <1 s for 10% step to within 1 mA of output into nominal load
**Modulation response:** ≤0.17 Hz at ±70 A sine wave into nominal load, <0.02% THD; ≤1 Hz at ±10 A sine wave into nominal load, <0.05% THD; ≤10 Hz at ±1 A sine wave into nominal load, <0.10% THD
**Attenuation:** -0.5 dB at 10 Hz
**Protection:** Short circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, and over temperature
**Connector:** Two lugs with 6.4 mm (0.25 in) holes for M6 or 0.25 in bolts

## Output Programming
**Internal current setting**
**Resolution:** 0.1 mA (20-bit)
**Settling time:** 600 ms for 1% step to within 1 mA (of internal setting)
**Accuracy:** ±10 mA ±0.05% of setting
**Operation:** Keypad, computer interface
**Protection:** Programmable current setting limit

**Internal current ramp**
**Ramp rate:** 0.0001 A/s to 50.0000 A/s (compliance limited)
**Update rate:** 23.7 increments/s
**Ramp segments:** 5
**Operation:** Keypad, computer interface
**Protection:** Programmable ramp rate limit

**External current programming**
**Sensitivity:** 10 V/70 A
**Resolution:** Analog
**Accuracy:** ±10 mA ±1% of setting
**Input resistance:** 20 kΩ
**Operation:** Voltage program through rear panel, can be summed with internal current setting
**Limits:** Internally clamped at ±10.1 V and bandwidth limited at 40 Hz to protect output
**Connector:** Shared 15-pin D-sub

## Readings
**Output current**
**Resolution:** 0.1 mA
**Accuracy:** ±10 mA ±0.05% of rdg
**Update rate:** 2.5 rdg/s display, 10 rdg/s interface

**Output voltage (at supply terminals)**
**Resolution:** 1 mV
**Accuracy:** ±5 mV ±0.05% of rdg
**Update rate:** 2.5 rdg/s display, 5 rdg/s interface

## Front panel

**Display type:** 8-line by 40-character graphic vacuum fluorescent display module
**Display readings:** Output current, output voltage, and internal water temperature
**Display settings:** Output current and ramp rate
**Display annunciators:** Status and errors
**LED annunciators:** Fault, Compliance, Power Limit, Ramping, Remote
**Audible annunciator:** Errors and faults
**Keypad type:** 26 full-travel keys
**Keypad functions:** Direct access to common operations, menu-driven setup
**Power:** Green flush ON and red extended OFF push buttons

## Interface

### IEEE-488.2 interface

**Features:** SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
**Reading rate:** To 10 rdg/s
**Software support:** National Instruments LabVIEW™ driver (consult Lake Shore for availability)

### USB interface

**Function:** Emulates a standard RS-232 serial port
**Baud rate:** 57,600
**Reading rate:** To 10 rdg/s
**Connector:** B-type USB connector
**Software support:** National Instruments LabVIEW™ driver (consult Lake Shore for availability)

### Output current monitor

**Sensitivity:** 7 V/70 A
**Accuracy:** ±1% of full scale
**Noise:** 1 mV RMS
**Source impedance:** 20 Ω
**Connector:** Shared 15-pin D-sub

### Output voltage monitor

**Sensitivity:** 3.5 V/35 V
**Accuracy:** 1% of full scale
**Noise:** 1 mV RMS
**Source impedance:** 20 Ω
**Connector:** Shared 15-pin D-sub

### Power supply cooling water

**Remote enable input:** TTL low or contact closure to enable output; jumper required if unused
**Valve power output:** 24 VAC at 1 A maximum, automatic or manual control
**Connector:** Shared 4-pin detachable terminal block
Flow switch and water valve optional

### Magnet cooling water

**Remote enable input:** TTL low or contact closure to enable output; jumper required if unused
**Valve power output:** 24 VAC at 1 A maximum, automatic or manual control
**Connector:** Shared 4-pin detachable terminal block
Flow, temperature switch, and water valve not included

### Auxiliary

**Emergency stop:** Requires 1 A, 24 VAC normally closed (NC) contact to enable power-up; jumper required if unused
**Fault output:** Relay with normally open (NO) or normally closed (NC) contact, 30 VDC at 1 A
**Remote enable input:** TTL low or contact closure to enable output; jumper required if unused
**Connector:** Shared 8-pin detachable terminal block
Emergency stop and inhibit switches not included

## General

### Line power

**Power:** 5500 VA max
**Voltage and current:** 200/208 VAC ±10%, 13 A/phase; 220/230 VAC ±10%, 12 A/phase; 380 VAC ±10%, 7 A/phase; 400/415 VAC ±10%, 6.5 A/phase
**Protection:** 3-phase thermal relay with adjustable current setting; two class CC 0.25 A fuses; over-voltage lockout circuit
**Frequency:** 50 Hz or 60 Hz
**Configuration:** 3-phase delta
**Connector:** 4-pin terminal block
**Features:** Soft start circuit, rear panel voltage selection indicator
Line voltage must be specified at time of order but is field reconfigurable; cable from power supply to facility power not included

### Cooling water

**Flow rate:** 5.7 L (1.5 gal)/min minimum
**Pressure range:** 34 kPa (5 psi) to 552 kPa (80 psi)
**Pressure drop:** 10 kPa (1.5 psi) at 5.7 L (1.5 gal)/min minimum for power supply only
**Temperature:** 15 °C to 30 °C (non-condensing)
**Connection:** Two 10 mm (0.38 in) hose barbs
**CAUTION:** Internal condensation can cause damage to the power supply

**Enclosure type:** 7 U high, 19 in rack mount with integral rack mount ears (25 mm (1 in) air space required on each side for ventilation)
**Size:** 483 mm W × 310 mm H × 572 mm D (19 in × 12.2 in × 22.5 in) with handles removed
**Weight:** 74 kg (163 lb)
**Shipping size:** 635 mm W × 559 mm H × 736 mm D (25 in × 22 in × 29 in)
**Shipping weight:** 79.5 kg (175 lb)
**Ambient temperature:** 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C at reduced accuracy
**Humidity:** Non-condensing
**Warm-up:** 30 min at output current setting
**Approvals:** CE mark pending—low voltage compliance to EN61010-3, EMC compliance to EN55022-1

## Ordering Information

| Part Number | Description |
|---|---|
| **643-204** | Model 643 ±70 A ±35 V, 2.5 kW, 204/208 VAC |
| **643-225** | Model 643 ±70 A ±35 V, 2.5 kW, 220/230 VAC |
| **643-380** | Model 643 ±70 A ±35 V, 2.5 kW, 380 VAC |
| **643-408** | Model 643 ±70 A ±35 V, 2.5 kW, 400/415 VAC |

**Accessories Included**

| | |
|---|---|
| **6031** | Two front handles |
| **6032** | Two rear handles |
| **6051** | Terminal block, 4-pin |
| **6052** | Terminal block, 8-pin |
| **6252** | 15-pin D-sub mating connector, analog I/O |
| — | Hose clamps |
| — | Power cable strain relief (power cable not included) |
| — | Calibration certificate |
| **MAN-643** | Model 643 user manual |

**Accessories Available**

| | |
|---|---|
| **6201** | 1 m (3.3 ft long) IEEE-488 (GPIB) computer interface cable assembly |
| **6261** | 3 m (10 ft) magnet cable kit, AWG 4t |
| **6262** | 6 m (20 ft) magnet cable kit, AWG 4 |
| **CAL-643-CERT** | Instrument recalibration with certificate |
| **CAL-643-DATA** | Instrument recalibration with certificate and data |
| **6041** | Water flow switch |
| **6042** | Water valve |

*All specifications are subject to change without notice*